AUTHOR RESPONSE

Referee: 1

COMMENTS TO THE AUTHOR(S)
The authors have addressed all my comments and incorporated discussions on the uncertainty and limitations of the presented results.

We're glad our revisions have adequately addressed your comments.

Referee: 2

COMMENTS TO THE AUTHOR(S)
Thank you for revising the manuscript and responding to the comments. While I can understand the author's claim, the claim appears to overreach the supporting evidence. I still do not think that the responses and the revisions justify attributing the mortality to temporal changes in NDVI and applying a single risk function across the world. A lack of appropriate evidence does not warrant the use of evidence that is not fit for the intended purpose. It should be demonstrated that the result of the meta-analysis captures the effect of temporal changes in NDVI. Applying a single risk function might be justified if the causal relationship and underlying physiological or pathological mechanisms are clear and expected to be common in humans, but this is not the case.

Thank you for your comments. We agree that this is a limitation of our approach, and of other analyses applying the Rojas-Rueda et al. (2019) exposure-response function to estimated health impacts of temporal trends in NDVI (e.g. Ji JS, Tao Z, Miao H, et al. Greenness and averted mortality in 390 cities in China (2000–2020). *The Lancet Regional Health - Western Pacific*. 2025;54:101283. doi:10.1016/j.lanwpc.2024.101283).

We've added to the discussion section the limitation of the spatial nature of the meta-analysis being applied to temporal differences in NDVI.

> *"Moreover, the studies included in the meta-analysis compare NDVI across locations. Our study assumes that the mortality relationships found when comparing spatial differences in NDVI can be applied to temporal differences."*

We have also expanded our discussion of how the limitation of using one exposure-response function globally adds to the uncertainty of our results.

> *"We use one exposure-response function globally from a large-scale meta-analysis that includes populations from the Northern America, Eastern Asia, Southern and Western Europe, and Australia and New Zealand regions, with significant representation of temperate and continental climates and limited inclusion of select arid and tropical cities, to be as generalizable as possible. However, most of the studies were conducted in Europe and North America in temperate and continental climate zones, where vegetation may differ from other climate zones. Fewer data points contribute to the exposure-*

response curve at very high or low NDVI levels, such as may be found in tropical or arid climates. The relationship between NDVI and all-cause mortality may be related to current NDVI levels and other factors that vary by region and climate. While some of the causal pathways that link NDVI to health, such as reduced stress from viewing greenspaces, are universal, others likely differ across climates. For example, increasing NDVI in arid climates may consist of adding vegetation which can survive in dry climates, which may provide less shade and relief from the heat than leafier plants requiring more water. Adding greenspace in arid climates could still provide health benefits through other pathways, such as providing natural beauty and places to exercise and gather. Additionally, spending more time outdoors may increase people's exposure to air pollution and accidents in developing cities with greater traffic and less regulations. We extrapolated the results of the meta-analysis, which largely consists of studies from developed countries in temperate and continental climates to a global set of cities. Thus, the uncertainty of our estimates is larger for cities in regions and climate zones not well-represented by the meta-analysis. These unmeasured sources of uncertainty are not captured by our error estimates.", lines 616-636.

It is necessary to limit the claim to reflect the existing evidence to assure the credibility of the study. For example, limiting the regional scope of the study to the developed countries in the temperate climate zone and estimating the mortality difference between factual and counterfactual scenarios (not temporal changes) would be an alternative option.

Thank you for your comments. We have added text to be clear about what regions and climate zones were included in the meta-analysis from which we draw our exposure-response function and to state that our results are less certain for cities outside these regions and climate zones (see response to the reviewer's first comment above). Most of the cities included in the meta-analysis fall in either temperate or continental climate zones, however there are some arid cities in China included from the Ji et al., 2019 paper and some tropical cities in Florida, USA included from the James et al., 2016 paper.

Referee: 3

COMMENTS TO THE AUTHOR(S)
I thank the authors for addressing the comments.

Re the uncertainty:
- There is no mention of how uncertainty is assessed in the revised manuscript.
- I understand the issues about computational burden, but from a probability standpoint, simply using the bounds of HR and y_0 to derive the confidence intervals is wrong. Two random variables are at play here.

Thank you for your comments. We have now run a Monte Carlo simulation of 10,000 draws from a normal distribution of both the hazard ratio and mortality rates to more accurately capture the known uncertainty from multiple variables. We have updated all references to 95% confidence intervals throughout the paper to reflect these simulations, using the 2.5th and 97.5th

percentile of the simulated means as our uncertainty interval. Figure S7 (formerly S6) and Table S1-3 have also been updated.

We have updated the methods section to describe this change:

> *"Quantifying uncertainty*
>
> *We ran 10,000 Monte Carlo simulations of Equation 3 for each city to estimate uncertainty intervals of our mortality estimates from changes in NDVI. We used estimates of error provided in the meta-analysis and by the GBD study to draw from normal distributions of the hazard ratio and baseline mortality estimates. For each simulation, the same draw of the hazard ratio was used for all cities.", lines 182-187.*

We have further included more text in the discussion section to describe unmeasured sources of uncertainty and how we might expect these sources to impact our results:

> *"We use one exposure-response function globally from a large-scale meta-analysis that includes populations from the Northern America, Eastern Asia, Southern and Western Europe, and Australia and New Zealand regions, with significant representation of temperate and continental climates and limited inclusion of select arid and tropical cities, to be as generalizable as possible. However, most of the studies were conducted in Europe and North America in temperate and continental climate zones, where vegetation may differ from other climate zones. Fewer data points contribute to the exposure-response curve at very high or low NDVI levels, such as may be found in tropical or arid climates. The relationship between NDVI and all-cause mortality may be related to current NDVI levels and other factors that vary by region and climate. While some of the causal pathways that link NDVI to health, such as reduced stress from viewing greenspaces, are universal, others likely differ across climates. For example, increasing NDVI in arid climates may consist of adding vegetation which can survive in dry climates, which may provide less shade and relief from the heat than leafier plants requiring more water. Adding greenspace in arid climates could still provide health benefits through other pathways, such as providing natural beauty and places to exercise and gather. Additionally, spending more time outdoors may increase people's exposure to air pollution and accidents in developing cities with greater traffic and less regulations. We extrapolated the results of the meta-analysis, which largely consists of studies from developed countries in temperate and continental climates to a global set of cities. Thus, the uncertainty of our estimates is larger for cities in regions and climate zones not well-represented by the meta-analysis. These unmeasured sources of uncertainty are not captured by our error estimates.", lines 616-636.*

Referee: 4

COMMENTS TO THE AUTHOR(S)
The authors have addressed all the questions that I proposed.

We're glad our revisions have adequately addressed your comments.

Referee: 5

COMMENTS TO THE AUTHOR(S)

EDITORIAL BOARD MEMBER'S REPORT:
The manuscript was improved and clarified in response to the comments from 4 reviewers, and most review comments were properly responded. However, some minor issues remain.

1) The main conclusions of this meta analysis is based a simple statistical approach with 2014-2023 NDVI time series, and there is a major uncertainty and limitation. Suggest to further extend discussion to highlight the limitation and uncertainty, and explain the key mechanisms behind NDVI driven morality across different climate zones.

Thank you for your comments. To address your comment, we have run a Monte Carlo simulation to estimate uncertainty intervals of our mortality estimates from changes in NDVI and added text changes to the Methods section as well as updated the reported 95% uncertainty intervals to reflect this analysis.

Methods section changes:

> *"Quantifying uncertainty*
>
> *We ran 10,000 Monte Carlo simulations of Equation 3 for each city to estimate uncertainty intervals of our mortality estimates from changes in NDVI. We used estimates of error provided in the meta-analysis and by the GBD study to draw from normal distributions of the hazard ratio and baseline mortality estimates. For each simulation, the same draw of the hazard ratio was used for all cities.", lines 182-187.*

We've further added to the discussion section the limitation of the spatial nature of the meta-analysis being applied to temporal differences in NDVI.

> *"Moreover, the studies included in the meta-analysis compare NDVI across locations. Our study assumes that the mortality relationships found when comparing spatial differences in NDVI can be applied to temporal differences."*

Additionally, we have added text to the discussion section to better explore the uncertainties of applying the exposure-response function from the meta-analysis to cities from climate zones and regions outside its scope.

> *"We use one exposure-response function globally from a large-scale meta-analysis that includes populations from the Northern America, Eastern Asia, Southern and Western Europe, and Australia and New Zealand regions, with significant representation of temperate and continental climates and limited inclusion of select arid and tropical cities, to be as generalizable as possible. However, most of the studies were conducted in Europe and North America in temperate and continental climate zones, where vegetation may differ from other climate zones. Fewer data points contribute to the exposure-response curve at very high or low NDVI levels, such as may be found in tropical or arid*

climates. The relationship between NDVI and all-cause mortality may be related to current NDVI levels and other factors that vary by region and climate. While some of the causal pathways that link NDVI to health, such as reduced stress from viewing greenspaces, are universal, others likely differ across climates. For example, increasing NDVI in arid climates may consist of adding vegetation which can survive in dry climates, which may provide less shade and relief from the heat than leafier plants requiring more water. Adding greenspace in arid climates could still provide health benefits through other pathways, such as providing natural beauty and places to exercise and gather. Additionally, spending more time outdoors may increase people's exposure to air pollution and accidents in developing cities with greater traffic and less regulations. We extrapolated the results of the meta-analysis, which largely consists of studies from developed countries in temperate and continental climates to a global set of cities. Thus, the uncertainty of our estimates is larger for cities in regions and climate zones not well-represented by the meta-analysis. These unmeasured sources of uncertainty are not captured by our error estimates.", lines 616-636.

2) Figure 1 doesn't present clear trends or temporal/spatial contrasts among regions, and the crowded curves in figures are quite confusing. suggest to further define the figure by using highly summarized data instead to better reflect key patterns.

Thank you for this feedback. We have updated Figure 1 to provide results summarized at the regional and climate classification levels separately and removed the individual city lines to provide more clarity. We moved the previous Figure 1 in the Supplemental Material (Figure S3).
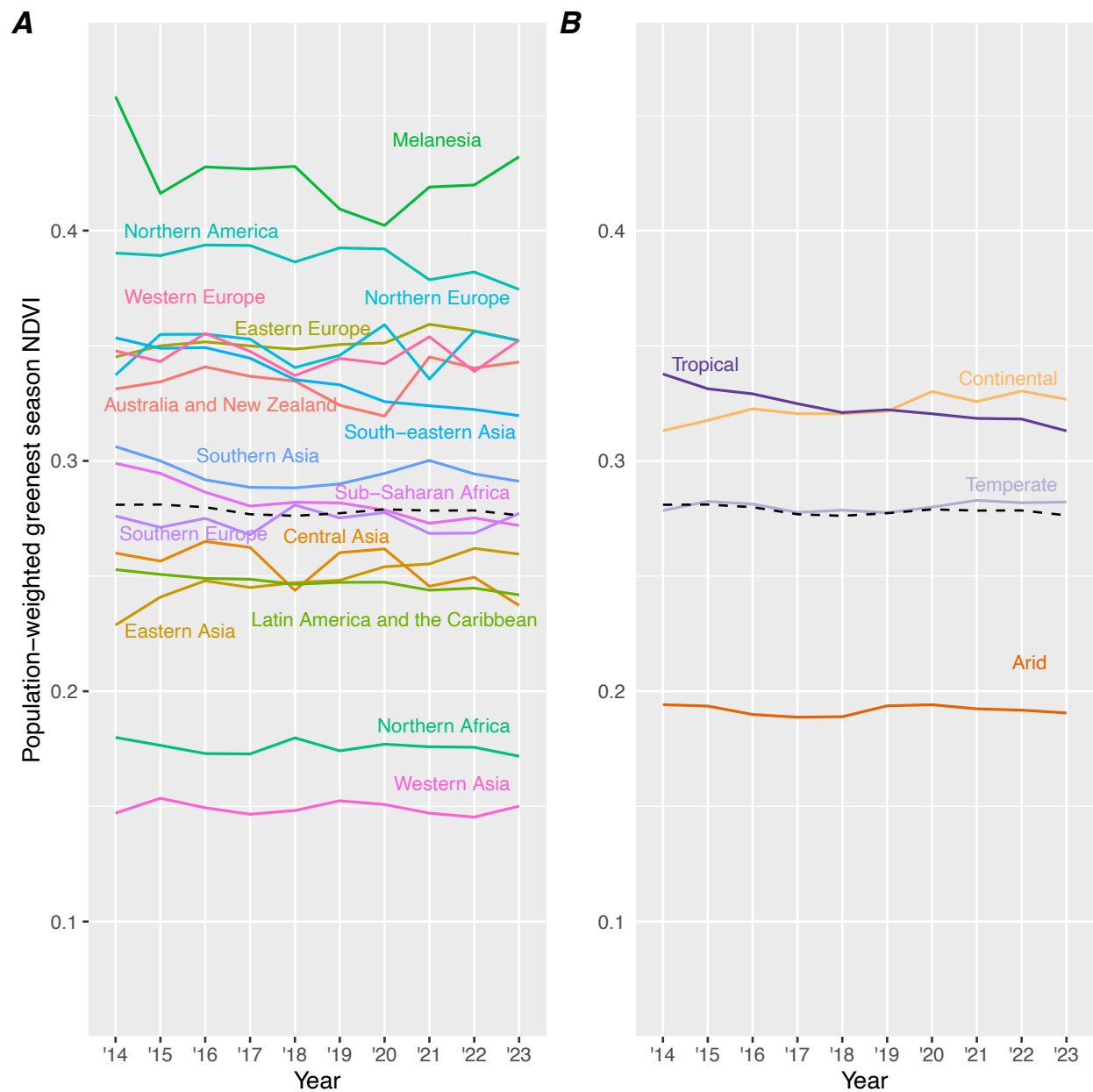
Figure 1. *Population-weighted greenest season average Normalized Difference Vegetation Index (NDVI) from 2014-2023 by geographic region (panel A) and climate classification (panel B). The 1,041-city average is shown with the black dashed line. The polar climate classification was removed from panel B, because only one city from this climate zone is included in the analysis (El Alto, Bolivia).*